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Breaking the Barriers to Meaningful Learning of Flowchart and Algorithm in Secondary School: Mobile Learning in Action

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ABSTRACT

The underperformance of secondary school students in computer studies is a major concern for technology advancement in Africa, particularly in Nigeria. Despite efforts to implement various pedagogical tools, satisfactory results have yet to be achieved. The study is concerned with the unsatisfactory sinusoidal wave-like performance of secondary school students in Nigeria in Computer science. It explored the potency of the Mobile learning systems in breaking the barriers to meaningful learning of flowchart and algorithm which is perceived as a difficult concept among the majority of the students. A total of 123 (experimental= 56; control= 67) students offering computer studies in the two public senior secondary schools (intact classes) made the study sample. The study employed an explanatory sequential design (quasi-experimental and interviews). The data for the quasi-experimental phase were obtained through the Achievement Test in Flowchart and Algorithm (ATFA) which had a reliability coefficient of which range from 0.72 to 0.83. The experimental group was taught using a mobile learning system (cSimplify), while the control group was taught using the lecture method. The result obtained showed that the experimental group outperformed the (mean for experimental = 25.14; control 17.99; $[F(1,120)=79.53; p<.05]$ control group. Difference in gender-based performance in the experiment group also attained a statistical significance. We concluded that Mobile Learning System (MLS) is a dependable pedagogical approach for promoting meaningful learning and breaking barriers to difficult concepts in computer science.

Keywords: Computer studies; Mobile learning; Flowchart; Algorithm; Secondary school; Meaningful learning

1. INTRODUCTION

In the dynamic landscape of modern education, computer studies emerge as a cornerstone subject, integral to preparing students for the technological complexities of the 21st century. However, despite its pivotal role, attaining and retaining knowledge in this field among secondary school students in Africa, particularly in Nigeria, presents a formidable challenge. As documented by research According to Adekoya (2018), this struggle is not just a story, but rather a significant issue rooted in educational landscapes. Integrating technology into the curriculum is crucial for fostering a technologically adept generation in Nigeria.

The emergence of computer science is widely acclaimed as one of the branches of modern science. This notion is partly due to the highly advanced usage of electronic technology and programming techniques in the modern-day human environment. “The use of computers is increasingly becoming indispensable as many tasks previously carried out manually at homes, schools, industries, communities, offices among others are now being automated at a very high speed through the flash of light" (Akinola, Richard & Babarinde, 2018).

A study by Rocha et al., (2023), revealed that there was hardly any human activity then that does not depend on using computers owing to its unique functions and relevance in society. This was corroborated by Ahmed, Urmi & Tasmin, (2020), stating that the acquisition of computer knowledge in Africa is a prerequisite for refocusing industrialization through engineering technology and national development. Globally, the application of computer education is enormous to foster rapid development. Primarily some areas of its application include internet application, Geographic Information System (GIS), programming, and data processing (Rocha et al., 2023; Olelewe, Agomuo & Obichukwu, 2019; Sharmin, & Chow, 2020).

In a report of a survey of the difficult concepts in computer studies curriculum for senior secondary school conducted by Okebukola et al., (2019), flowchart was reported as the most difficult concept followed by the algorithm in computer studies, and the preponderant reason for the difficulty is largely associated with the teaching methods or strategies adopted in teaching the concept as reported in the study. Over the years, Africa has largely adopted different teaching methods, many of which have proven not to be suitable for the African environment. Some of these methods isolate African learners from their communities and infuse them with Western values, customs, attitudes, and knowledge systems (Jophus, 2020). The use of a teaching strategy developed within the African context which recognizes the richness of African cultural/indigenous knowledge and promotes the use of community knowledge and locational context in educational discourses might just be a way to achieve the desired performance level of students in computer studies.

There is a lack of effective teaching techniques for Nigeria's secondary schools, which is hindering academic progress and the development of essential problem-solving and technological skills. Some suggested interventions include changing the curriculum, exploring challenging topics, using improvised materials, emphasizing textbooks, promoting student-centered approaches, improving teacher quality, and increasing training for computer teachers. Despite these efforts, there has been little improvement in academic achievement. Although indigenous teaching methods are a new concept, they have the potential to engage students more effectively and promote deeper understanding beyond just memorization (Ajayi & Omotunde, 2020).

Digging deep, there is a significant gap in the integration of mobile learning systems that needs to be addressed. Although the use of mobile devices among secondary school students is becoming more common, research on mobile learning and mobile technology acceptance in secondary education is still limited.The poor performance of students in computer studies is attributed to the incorrect use of application packages and poor practical skills, according to the WAEC Chief Examiner's report in 2019. Introducing a mobile learning system would be a welcome development to reduce poor student achievement and retention in computer studies, especially in senior secondary schools and for job-related opportunities. Often, youths and students become so excited about acquiring computer-related devices that they neglect to fully understand the components that make up the device.

In modern education, we strive to enhance learning experiences by moving away from outdated teaching methods that can hinder students' understanding and instead focusing on innovative approaches that foster comprehension and engagement. In light of these considerations, this study endeavors to bridge the gap in the literature by exploring the efficacy of mobile learning as a catalyst for breaking down the barriers to meaningful comprehension of flowchart and algorithm in African, Nigeria secondary schools. By harnessing the ubiquity of mobile devices and leveraging interactive learning platforms, this research seeks to not only enhance students' conceptual understanding but also cultivate a deeper appreciation for computational thinking and problem-solving skills essential for success in the digital age.

2. TRENDS IN STUDENTS' ACHIEVEMENT IN COMPUTER STUDIES IN NIGERIA

Computer Studies and Modern Education

Computer studies have become incredibly important in modern education worldwide. The ability to navigate and use technology has become an essential part of daily life, with technological advancements happening at an unprecedented rate. However, despite the significance of computer studies in scientific, non-scientific, and societal advancements, there is a growing concern about students' performance in learning this subject. Academic achievement is a critical aspect of this discussion, as it measures the extent to which students have mastered a particular course of study. According to Omachi (2000), academic achievement refers to the scholastic standing of a student's performance at a specific time, including cognitive scores or learning outcomes in a subject. It showcases the successful attainment of educational objectives.

The assessment of academic achievement serves to assist both teachers and students in evaluating and appraising the degree of success attained in learning a specific concept, thereby gauging the efficacy of instructional methods. Consequently, all pedagogical endeavors revolve around the academic achievement of students. Notably, internal and external examinations in computer studies at the senior secondary level have consistently revealed subpar performance among students over the years.

Numerous studies have examined the performance of high school students in computer studies in Africa, intending to identify common trends and challenges. Among the factors that have been identified as contributing to poor performance in this subject are ineffective teaching methods, inadequate computer facilities in many schools, a lack of skilled teachers who are proficient in the subject matter, and insufficient use of illustrative examples. These factors all contribute to students' difficulty in grasping key concepts.

Additionally, low integration of ICT in teaching and learning, inadequate learning facilities, lack of pedagogical content knowledge among teachers, and ineffective teaching approaches have been identified as significant impediments. Research conducted by Gachago and Mwangi (2019) in Kenya underscored the pivotal role of factors such as the availability of computers, teacher training, and access to computer labs in influencing students' performance in computer studies. Similarly, a study by Mohammed and Ali (2019) in Eritrea highlighted the significance of students' prior knowledge, teacher qualifications, and availability of resources in determining their performance in this subject. The findings of these studies underscore the imperative for governments to allocate more resources and enhance teacher training to elevate the standard of computer science education.

There is abundant evidence suggesting that many teachers in Africa lack the requisite pedagogical content knowledge and skills necessary for effective teaching (Yadav & Berges, 2019; Mtebe & Raphael, 2018; Chukwuemeka et al., 2019). Additionally, resources such as computer technologies that facilitate learning are either inadequate or not readily available in many African schools (Oladejo, 2018). The conventional teaching approaches employed in classrooms over the years appear ill-suited to the African curriculum, as evidenced by reports of underperformance in STEM subjects, including computer studies, across many African countries (Ibikunle, 2014; Sanni & Fakunle, 2016). These factors significantly impact students' achievement and attitude toward learning.

Of particular interest among the myriad of factors contributing to students' underperformance is the prevalence of ineffective teaching approaches. The predominant teacher-centered approach, long employed in teaching computer studies, has been identified as a major contributor to students' lackluster performance in STEM subjects, including computer studies (Oguguo et al., 2020). In this traditional method, teachers serve as the primary source of information, transmitting knowledge to passive recipients. However, in the era of ICTs, the role of teachers has evolved from mere disseminators of knowledge to collaborators and co-learners (Usman & Madudili, 2020). ICTs have assumed a pivotal role in fostering collaboration and enhancing teaching and learning activities, benefiting both educators and learners alike (Chatti & Majeed, 2022).

At the secondary school level, teachers often lament the apparent disinterest and frustration exhibited by students when confronted with challenging topics in computer studies, such as Flowcharting, Algorithm, and Problem-solving skills (Sharmin & Chow, 2020; Qureshi et al., 2020). Failure to grasp these fundamental concepts could lead to a loss of interest in computer science and, consequently, poor academic performance (Abayan, 2012; Lavanya, 2020). These foundational topics serve as the cornerstone for understanding more complex programming languages and other advanced concepts in computer studies. Moreover, inadequate practical classes and a dearth of illustrative examples exacerbate students' difficulties in comprehending these topics (Okebukola et al., 2020).

The goal of learning is to acquire knowledge that can be applied to solving societal problems and used for the development of any nation. To achieve this goal in Nigeria and other parts of Africa, there is a need to adopt and use the pedagogical tool(s) that best suit the context of the learners which will enable them to learn meaningfully, think critically and with which contemporary issues in Nigeria and other parts of Africa can be solved and sustainable development can be attained. One of the other learning tools is the indigenous knowledge.

There are widespread claims about the effectiveness of indigenous knowledge in improving students' performance, but very little documentation has been recorded on its effectiveness in computer studies.

In addition, very few studies have been carried out on the use of mobile learning systems to bolster the poor performance of secondary school students in computer studies in Nigeria.
Hence, this study is conceived to fill these gaps.

Why Flowchart and Algorithm?
A study conducted by Okebukola et al. (2020) ranked concepts in computer studies curriculum for senior secondary schools in Africa in order of difficulty from the most perceived difficult concept to the least. The study surveyed 1,177 secondary computer studies students who were randomly selected from public and private schools in urban and rural arrears of Nigeria and Ghana. Flowcharting which is one of the building blocks of programming language has been rated as the most difficult concept in Computer Studies (see Table 1).

Table 1: Ranking of Difficulty Concepts in Computer Studies (N=1,177)

S/N	Topics	Mean score	Rank
1	Flowcharting	2.12	1st
2	Algorithm	2.07	2nd
3	Problem solving skills	2.00	3rd
4	Program development cycle	1.96	4th
5	Machine language	1.91	5th
6	Computer Ethics and human issues	1.84	6th
7	Logic circuit	1.82	7th
8	Computer fundamentals and evolution	1.81	8th
9	Networking	1.77	9th
10	Arithmetic logic unit	1.74	10th
11	Managing computer files	1.73	11th
12	BASIC programming	1.65	12th
13	Computer applications	1.55	13th
14	Booting	1.53	14th
15	Telecommunication	1.53	14th
16	Basic computer operations	1.49	16th
17	Binary numbers	1.45	17th
18	Operating system	1.44	18th
19	Components of a computer system	1.35	19th

Okebukola et al., 2020

As seen in Table 1, flowcharting with a mean score of 2.12 was perceived most difficult concept in computer studies by the students followed by algorithm ranked 2nd with a mean score of 2.07. These two topics were selected for this study because it was reported that students found them difficult to understand due to insufficient examples and not enough practical classes were used to buttress the explanation of the concepts. The underperformance of students in computer studies has been a major concern of science educators in Africa particularly Nigeria.

Evidence abounds that students perform poorly in terms of achievement in secondary school students towards learning computer studies (Saanu, 2015; Musau & Abere, 2015). Efforts to curtail this underperformance by researchers, science educators, and science teachers have not yielded the desired positive results as the poor performance of students persists both in internal and external examinations.

However, many of these efforts have been able to provide insights into the factors influencing students' performance in computer studies. These factors include but are not limited to teaching methods, unavailability of computer facilities in many schools, lack of skilled teachers to teach the subject, and inadequate use of examples and illustrations all of which cause students' difficulty in understanding the concepts in the subject (Agbanimu, 2020; Gbeleyi, 2020; Ebisin, 2020; Peter, 2020).

Cognitive Theory of Multimedia Learning

With the three assumptions underlying the *cognitive theory of multimedia learning*, Mayer (2014) described why learning with digital tools can be beneficial: According to the *dual-channel assumption*, learners can organize information into two different cognitive structures, namely the visual and the auditory channels. The second assumption is the *limited capacity* of information processing in one channel. Therefore, it is favorable if learning environments stimulate the activation of both channels, the visual and auditory channels, to prevent cognitive overload. This is possible, for example, by presenting sound images or spoken texts in combination with written texts or visual images. The third assumption is that learners need to engage *actively* with learning content to comprehend new information (Mayer, 2014). This is possible by the use of interactive learning environments, where the learner can actively and directly influence their learning processes. In other words, "the defining feature of interactivity is responsiveness to the learner's action during learning" (Moreno & Mayer, 2007, p. 310).

Such interactivity can be further categorized into dialoguing, controlling, and manipulating: Dialoguing means that the learner receives additional information on demand or feedback on his or her entered solutions. Interactivity by controlling occurs when the learner determines his or her learning pace or the preferred order of presentation. Finally, the learner can interact with learning environments by manipulating the presented information. This means that he or she "can control aspects of the presentation, such as setting parameters before a simulation runs, zooming in or out, or moving objects around the screen" (Moreno & Mayer, 2007, p. 311). Thus, in contrast to other instruction methods without these interactive features—where the learner passively receives information—an interactive learning environment enables learners to act as sense-makers constructing their knowledge. Because "deep learning depends on cognitive activity" (Moreno & Mayer, 2007, p. 312) interactive tools are supposed to support student learning by offering specific characteristics such as dialoguing, controlling, or manipulating.

Mobile Learning and Students' Achievement STEM Subjects

Mobile learning systems in Africa have been instrumental in enhancing basic literacy skills, numeracy, and promoting lifelong learning. Numerous mobile learning applications and platforms have been developed to address specific educational needs, such as literacy apps like Kytabu in Kenya, which provide access to digital textbooks and learning resources (Otieno and Taddese, 2020). Mobile learning interventions have demonstrated effectiveness in improving reading and comprehension skills, particularly in low-resource settings (Alotaibi and Zeidan, 2023).

Mobile learning systems have been utilized to enhance teacher training and professional development in Africa. Mobile platforms, such as Ubongo Teacher's Companion in Tanzania, provide teachers with access to instructional resources, lesson plans, and professional learning communities (Mahundu, 2020).

Numerous mobile learning applications have been developed specifically for the African context. These apps cover a wide range of subjects and educational levels, from basic literacy and numeracy skills to advanced courses in various disciplines. They often feature interactive content, quizzes, videos, and gamification elements to engage learners and facilitate knowledge retention. In some cases, due to the prevalence of feature phones in many parts of Africa, mobile learning systems take the form of SMS-based learning. This approach utilizes text messaging to deliver educational content, assessments, and reminders to learners' mobile phones. It is a cost-effective method that requires only basic mobile connectivity. Many educational institutions and organizations have also developed mobile-optimized websites or web-based platforms that provide access to educational materials, lectures, and online courses. These platforms are designed to be easily accessible and navigable on mobile devices, ensuring that learners can access content on the go.

Mobile learning systems in Africa often incorporate multimedia elements, such as audio and video resources, to cater to diverse learning styles and language preferences. These resources can be accessed through mobile applications, websites, or other digital platforms, allowing learners to engage with content dynamically and interactively. Additionally, some mobile learning systems offer offline learning options, allowing learners to download educational materials while connected to the internet and access them later without requiring a continuous internet connection. However, there was no consensus on the definition of a Mobile Learning System as many scholars defined Mobile Learning Systems in different contexts. This can be attributed to the fact that mobile learning systems have two distinctive components, notably mobile and learning. The lack of common understanding develops due to different perspectives from which is viewed by different scholars. According to Geddes, (2000 as cited in Qureshi et al., 2020) he sees m-learning system as, “the acquisition of any knowledge or skill through using mobile technology, anywhere and anytime.” Geddes was of the view that knowledge and skills could be sourced using any medium but such information that is gotten through the use of technology follows a more longitudinal spectrum. Meanwhile, Lozanova, (2023) perceives it as a mobile learning model which allows learners to obtain learning materials using mobile technologies.

Omar and Ismail, (2020) were of the perception that mobile learning systems can simply be defined as, "the process of connecting mobile devices to the Internet for educational exploits and information sourcing. Also, a more functional definition exists as, *“the exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning in establishments and schools…”* (Qureshi et al., 2020). Mobile devices have become much cheaper, more powerful, and more accessible than conventional computers (Qureshi et al., 2020). Among contemporary secondary school students, various studies alluded that mobile learning systems have become relatively popular and suitable for learning among students as these devices become more affordable resulting in widespread ownership (Abachi & Muhammad, 2014; Sharmin & Chow, 2020).

The National Policy on Education, NPE (2014), stipulates that every learner must be exposed to computer studies and ICT in schools. This is because education has taken on a new dimension globally. As a result, at the upper basic education level, computer science courses are offered as a compulsory subject for all students at any level. Students find the use of its devices interesting, but in the course of teaching this subject in classrooms, some parts of the gadget, its language, and usage seem like a mirage and difficult for the students to comprehend (Pardaboyevich et al., 2020 & Maraví, 2021).

Education has taken advantage of computer technology which could enhance and improve the teaching and learning process. The traditional classroom, teacher, textbooks, and blackboard can no longer satisfy the needs of generations of students used to handling technological tools from a very young age. Mobile devices allow learning in motion, making the learning process more appealing, interesting, and motivating as today's students come to class armed with smartphones, tablet PCs, laptops, and iPods (Bi & Huang, 2021). Mobile learning provides an abundance of benefits to schools in which the engagement of learners and teachers increases as course contents can be accessed anywhere, anytime (Andre, 2020).

The use of mobile learning systems has been found to improve students' academic performance in African schools, particularly in STEM subjects. Mobile learning systems have the potential to increase access to education, improve learning outcomes, and enhance the quality of education in African schools. According to UNICEF, about 30 million children in sub-Saharan Africa are out of school. Mobile learning systems can help bridge this gap by providing students with access to educational resources, even in areas where there are no schools or teachers available. For example, the education Alliance project in Tanzania used mobile phones to provide primary school children with access to educational content. The project showed that mobile phones could be an effective way to deliver education to children in rural areas.

Mobile learning systems has also been found to contribute to improvement in students' learning outcomes. A study conducted in Ghana, Adu and Ofori-Dwumfuo (2020) found that the use of mobile learning systems improved students' performance in English language and mathematics. The study concluded that mobile learning technology could be used as an effective tool to improve students' academic performance in African schools. Similarly, in a study conducted by Matengo and Ntalasha (2018) in Zambia, it was found that the use of mobile learning systems improved students' performance in social studies.

Beyond its impact on improving students' academic achievement, mobile learning systems have contributed immensely to actively engaging students in learning activities. In a study conducted by Isaacs, Roberts & Spencer-Smith (2019), the researchers examined the use of mobile learning in a South African university and found that mobile learning had a positive impact on students' academic performance and improved their engagement and participation in learning activities. Similarly, a study by Mokgethi and Van der Merwe (2020) examined the use of mobile learning in a South African high school and found that it improved students' access to learning materials and increased their motivation to learn.

Another study by Okeke and Ezema (2018) investigated the use of mobile learning in a Nigerian university. The study found that mobile learning improved students' access to learning materials, increased their participation in class activities, and improved their academic performance. Similarly, a study by Muyinda and Mugagga (2018) examined the use of mobile learning in a Ugandan university and found that it had a positive impact on students' learning outcomes and engagement in learning activities. In a study by Papadakis (2022), the researchers investigated the use of mobile learning in Tanzanian secondary schools. The study found that mobile learning improved students' access to learning materials and increased their engagement in learning activities, leading to improved academic performance. Similarly, a study by Kiboss and Ng'eno (2020) examined the use of mobile learning in a Kenyan university and found that it improved students' access to learning materials, increased their motivation to learn, and improved their academic performance.

Some relevance of mobile learning is listed below;

1. Proper schedules are set by schools for students to learn.
2. Teachers can communicate on the go with students to clear their doubts.
3. Course materials can be conveyed effectively.
4. Different types of teaching methods and dynamic materials can be used to great effect.
5. M-learning can enhance learning by putting students in a real context and creating new learning environments.
6. Students could maximize their acquisition of skills, and competencies and optimize their time of studying.
7. Students could identify areas where they need assistance and support.
8. Mobile learning helps students to remain focused for longer periods.
9. It makes learning more accessible.

It is worth mentioning, however, that despite the relevance and benefits of mobile learning in African schools, several challenges are limiting its full exploration in many African schools. One of the main challenges is limited access to mobile devices and internet connectivity. In many African countries, mobile devices and internet connectivity are still expensive and not readily available to all students, limiting their access to mobile learning resources. Another challenge is the lack of infrastructure and technical support for mobile learning systems in many African schools, which can make it difficult to implement and maintain such systems.

In a study by Ng'ambi and Lombe (2019), the researchers examined the challenges of implementing mobile learning in a South African university. The study identified several challenges, including limited access to mobile devices, limited internet connectivity, and the need for technical support and training for both teachers and students. Similarly, a study by Kikwati and Wanjohi (2020) examined the challenges of implementing mobile learning in a Kenyan university and found that limited access to mobile devices and internet connectivity were the main challenges.

Gender Influence in Learning Computer Studies

The underperformance of students in STEM has generated conflicting discourse in literature as to what factors are responsible for the poor performance. While there are various agents, such as the learners' background, teachers' pedagogical content knowledge, school environment, society, and government policy among others influencing the learning outcomes, gender is one of the most influencing factors that has been frequently mentioned in the literature. Gender is a broad analytical concept that draws out women's roles and responsibilities concerning those of men.

It deals with the socio-cultural classification of women and men. This classification is based on societal norms and values that define the roles men and women should play in society. As a result, females' decision to pursue STEM-related disciplines is influenced as they have been perceived by society as the weaker sex, not capable of handling complex tasks like their male counterparts. Concepts in computer studies and other STEM subjects are perceived to be technical/complex. To this end, women or girls have been observed to be underrepresented in computing and science-related courses. However, several empirical studies have been conducted to confirm or discard this societal belief and thus, encourage gender equality in all fields of study. Research findings on academic performance due to gender are at variance. Differences in academic achievement due to gender have caused a lot of concern to educationists (Oladejo et al., 2021).

Gender has been identified as a major factor that affects students' achievement in mathematics, science, and technology (Omiko, 2017). In Nigeria for instance, women are marginalized while men are given greater opportunities to advance considering that they have a solid science background than their female counterparts (Alabi, 2014). Boys, therefore, appear to have a natural positive attitude to STEM subjects of which computer studies is inclusive while girls show a negative attitude. This negative attitude appears to be due to the acceptance of the myth that boys are better at science subjects than girls. Babajide (2010) further admitted that science subjects such as Biology, Physics, and Chemistry are given a masculine outlook by education practitioners.

Studies conducted across African countries, including Nigeria, have reported disparity in the education of girls and women in science and technology. This accounted for females' low contribution in the areas of Engineering, medicine, technology, and by extension the development of nations. Having a closer look at the effects of gender on each of the STEM subjects, there are variances in the findings as to whether gender has a significant impact on learning outcomes. A study conducted by Osadebe and Ogbomena (2018) to assess the demographic influence on students' performance in mathematics using a sample of 759 students (male and female) in Delta State, Nigeria, found that there is a statistically significant relationship between gender and students' performance in mathematics. This performance is in favor of male students.

According to Mayer (2020), gender disparities in computer studies in Africa are a significant concern. The study revealed that girls tend to perform lower than boys in computer science, mainly due to stereotypes and socialization processes. Similarly, a study conducted by Mugabi and Mugisha (2018) in Uganda found that girls generally score lower in computer studies than boys. The study attributed this to socio-cultural and economic factors that create gender stereotypes and restrict girls' access to technology. On the other hand, some studies have found no significant gender differences in performance in computer studies. For instance, a study by Ogbonna and Anyanwu (2019) in Nigeria found that there was no significant difference in performance between male and female students in computer studies. Similarly, a study by Mwageni (2017) in Tanzania found that both male and female students performed well in computer studies.

Socio-cultural and economic factors also contribute to gender differences in performance in computer studies. A study by Nwogu and Okereke (2017) found that socio-cultural factors, such as gender stereotypes and cultural expectations, play a significant role in the under-representation of females in computer studies. The study also identified a lack of role models, self-efficacy, and confidence as additional factors that affect female students' participation and performance in computer studies.

A more recent study by Abdi and Sallau (2020) also identified the lack of female role models and inadequate guidance and counseling services as factors that hinder female students' participation and performance in computer studies. In the same vein, a study conducted by Syed and Nelson (2019) found that gender stereotypes were a significant barrier for women in computer science. The study found that women were less likely to pursue computer science because of the belief that the field was more suitable for men. Another study by Watson et al. (2017) found that women who identified as feminists were more likely to pursue computer science.

To promote gender equity in computer studies, various strategies have been proposed. One such strategy is the provision of equal access to technology. Mugabi and Mugisha (2018) suggest that providing girls with equal access to computers and the internet can help bridge the gender gap in computer studies. Additionally, Anyanwu and Ogbonna (2018) propose that teachers should be sensitized on gender issues and trained on gender-responsive pedagogy to help reduce gender stereotypes in computer studies. Another strategy is the integration of computer studies into the curriculum from an early age. Mwageni (2017) notes that exposing children to technology from an early age can help promote interest and confidence in computer studies. Furthermore, Mayer (2020) suggests that introducing girls to female role models in computer science can help encourage and motivate them to pursue computer studies.

However, of notable recognition among the factors in literature is the teaching approach used in teaching computer studies in Africa particularly Nigeria. A study conducted by Ntoumanis et al. (2021) found that a problem-based learning approach was effective in promoting women's engagement and success in computer science. The study found that the approach provided a supportive environment that encouraged collaboration and problem-solving skills. This is in line with the study by Oyelere and Adebiyi (2018) who found that female students performed better when the teaching methods incorporated collaborative learning, active participation, and the use of real-life examples. In contrast, traditional lecture-based teaching methods were found to be less effective in engaging female students in computer studies.

Similarly, a study by Mbuva and Kimathi (2020) found that the use of instructional videos and visual aids improved female students' performance in computer studies. Some researchers (Olusegun and Adesoji 2017; Lee et al., 2023, and Saanu, 2015) also found that male and female students performed equally well in computer studies using self-instructional computer- based packages and indigenous knowledge. However, it is not clear how gender will influence learning when different strategies are used in teaching, hence the need to include gender in this study.

Given the high-status nature of computer science and the tremendous levels of power and influence that lies with those who have stature in this field, computer science education reform must prioritize addressing the complex ways that gender inequities operate and are reproduced in this discipline. Prior research in equity and computer science has illuminated how structural and belief systems collide to create obstacles for many students to learn computing in schools (Pedersen and Iliadis, 2020). Additionally, educator beliefs and practices, at the school and classroom level, profoundly impacted students' opportunities to learn computer studies through student tracking and enacted pedagogy in the classroom. This collision of structural and belief system biases in computing education results in significant and persistent participation gaps in computer studies by girls (Lang et al., 2020; Scott et al., 2019). This study intends to explore the relative effectiveness of MLS as a teaching approach to the academic achievement of male/female students in computer studies

Research Questions

The following research questions guided this study:

1. What impact has the use of mobile learning system on secondary school students' achievement in flowchart and algorithm?
2. Would the use of mobile learning application have a differential impact on student's achievement in flowchart and algorithm based on gender?

3. METHODOLOGY

Design

This study adopted mixed method research design using an explanatory sequential design which encompasses the quantitative and qualitative phases (Jaiyeola 2020; Fetters, Curry, and Creswell 2013). The quantitative phase of the study employed the quasi-experimental design using the pretest-posttest nonequivalent group design, while the qualitative phase adopted semi-structured in-depth interview from selected participants from the quantitative phase. The strength of this design is that it allowed us to use findings from the qualitative phase to provide an in-depth explanation of the results obtained from quantitative data analysis.

Participants and Study Context

We purposively selected two senior secondary schools from the population of students offering computer studies in year two (SS2) in Lagos State Education District V. The schools that participated in the study had a computer studies teacher and a record that the students offer the subject. The schools were located in separate areas of the education district to prevent interactions among the control and experimental subjects which may confound the results of the study. A total of 123 (experimental= 56; control= 67) students offering computer studies in the two public senior secondary schools (intact classes) made the study sample.

Procedure for Data Collection

The data for the quasi-experimental phase were obtained using Achievement Test in Flowchart and Algorithm (ATFA). ATFA is a multiple-choice test instrument containing 40 questions. The items were constructed following the 20 golden rules established by Okebukola (2015) and are in line with the WASSCE standard, where each option is attached to the questions. The team of experts comprises three computer studies teachers with over five years of teaching experience and have been involved in coordination exercises of WAEC SSCE and NECO SSCE script marking. The questions were evenly distributed across the cognitive process dimension (Anderson and Krathwohl, 2001) and each question carried equal score weight.

The instrument was validated, and its reliability was established using the split-half procedure (SPSS version 23 was used). The ATFA was used to test the prior knowledge of the students before the treatment (pretest), and the knowledge gained after the treatment (posttest). To strengthen our arguments in the discussion of findings beyond mere conjecturing and comparison with previous studies, we allowed the students to express their conceptual understanding as well as their perception about learning flowchart and algorithm using mobile learning and flipped classroom approach. This was done through a semi-structured interview with selected students.

The students who participated in the interview were selected based on their attendance and participation in the learning activities throughout the lesson periods (Jaiyeola, 2020). The selection was based on mixed sex and mixed ability ensuring a relatively triangulated data set. The interviews were conducted the day after the posttest in a relatively noise-free area of the school to avoid distractions and to make the students feel relaxed and comfortable. While securing their confidence and cooperation, each of the students was informed that the interview was not a test and thus, there were no right or wrong answers. They were also informed that the session was being recorded, while some salient points made by the students were noted, particularly, those expressed through gestures and non-verbal cues such as shaking of the head. Each session lasted about 15 minutes.

Treatment

After the conduct of the pretest, treatment began. This phase lasted for four weeks, and the teaching of the two groups on the concept of flowchart and algorithm. All lessons were slated for 80 minutes each which lasted for four weeks with the two groups. The treatment group , which was the ML group was taught using the mobile learning system "cSimplify" that was developed by me while the control group was taught using the traditional lecture method.

Procedure for Data Analysis

To answer the first and second research questions, we applied a one-way analysis of covariance (ANCOVA) on the students' pretest and post-posttest scores using IBM SPSS version 23. To justify the use of this statistical tool, two preliminary tests of parametric assumptions were conducted on the data and the results obtained (see tables 1 and 2) showed that the data satisfied the assumptions of homogeneity of variances with the Levene's test result not significant (F = 1.30; p= .28) implying no significant difference between the groups hence, comparable. The Shapiro–Wilk's test (as the Kolmogorov-Smirnov's test) of normality showed that the population from which the two groups were drawn is not significantly different from normal. The lecture method group: [(67) = .98; p= .42] and mobile learning group: [(56) = .98; p= .53]. The pre-test scores were used as the covariate to draw the two groups to the same base since randomization was not achieved.

Table 1: SPSS Output for the test of normality

Dependent variable	Method	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Achievement Posttest	Mobile learning group	.09	56	.20*	.98	56	.53
	Lecture method group	.08	67	.20*	.98	67	.42

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 2: SPSS Output for the test of homogeneity of variance

		Levene Statistic	df1	df2	Sig.
Achievement Posttest	Based on Mean	1.30	1	137	.28

4. RESULTS

Having met the parametric assumptions, we proceeded with the analyses using one-way ANCOVA for research question one. The result of the descriptive analysis (see Table 1) showed that students in the experimental group had a higher mean score (25.14) than their counterparts in the comparison group (17.99). However, to ascertain whether the observed difference can be considered statistically significant and not due to error variance, the obtained result was subjected to inferential testing and the obtained result is as shown in Table 3. The result in Table 4 shows that the observed difference in the mean scores of the control and experimental group is statistically significant. Thus, the experimental group performed significantly better than the comparison group [$F(1,120)=79.53$; $p<.05$].

On the second research question, the result of the descriptive analysis revealed that the males had a higher mean score (26.92) than the female students (23.81). A closer look at the pretest achievement row in Table 5 shows that at entry, the male and the female students in the experimental group were significantly different from one another on measure of achievement in flowchart and algorithm. Similarly, after treatment, the inferential statistic (one-way analysis of covariance) applied to the obtained data shows that the observed difference in the mean scores of the achievement of male and female student female and male students attain a statistical significance [$F(1,53)=9.67$; $p<.05$].

Table 3: Mean and Standard Deviation for the control and experimental groups

Dependent Variable: Achievement Posttest			
Method	Mean	Std. Deviation	N
Mobile learning group	25.14	4.60	56
Lecture method	17.99	4.97	67
Total	21.24	5.98	123

Table 4: ANCOVA summary table of difference in achievement of control and experimental groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Achievement Pretest	1113.56	1	1113.56	79.53	.00
Method	236.22	1	236.22	16.87	.00
Error	1680.28	120	14.00		

Table 5: ANCOVA summary table of difference in achievement of male and female students in the experimental group

/Dependent Variable: Achievement Post					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Achievement Pretest	265.72	1	265.72	18.41	.00
Gender	139.63	1	139.63	9.67	.00
Error	764.99	53	14.43		

5. DISCUSSION OF RESULTS

The focus of this study was to explore the relative effectiveness of mobile learning system on students' achievement in flowchart and algorithm as difficult concepts in computer studies. We approached solving the identified problem through an empirical investigation and we were guided by the two questions raised in the introductory part of this report. The first research question in this study sought the impact of using mobile learning system on secondary school students' achievement in flowchart and algorithm. As shown in Table 1, we found that students in the experimental group (taught with the Mobile Learning System) performed better than the control group (taught with the lecture method). This finding tallies with Studies by (Yıldız et al., 2020 and Kukulska-Hulme et al., 2016). These findings provide evidence that the method of instruction indeed influenced the students' academic performance. The statistically significant P value suggests that the mobile learning system has a substantial effect on student's overall academic achievement compared to the conventional lecture method. This finding is consistent with previous research that highlights the advantages of integrating technology-enhanced learning approaches in educational settings.

Previous research by Lee et al. (2016) and Al-Azawei et al. (2017) have demonstrated that multimedia-rich learning environments enhance cognitive processes and promote active learning, which may have contributed to the improved academic performance of students in the mobile learning group. In contrast, the conventional lecture method may not provide the same level of interactivity and multimedia resources, potentially limiting students' engagement and understanding of complex concepts like flowchart and algorithm. Traditional lecture-based teaching might not adequately address individual learning needs and preferences, as suggested by (Traxler, 2018 and Zheng et al., 2019).

Previous studies by Yıldız et al. (2020) and Kukulska-Hulme et al. (2016) have shown that mobile learning systems facilitate interactive and engaging learning experiences, leading to better knowledge retention and understanding among students. The result further supports the superior impact of the mobile learning system, indicating that students taught through this method outperformed their counterparts taught through conventional lecture-based teaching. The higher mean score obtained by students taught through the mobile learning system may be attributed to several factors. The mobile learning system offers interactive multimedia elements, such as flashcards, animations, games, and quizzes, which can cater to diverse learning styles and preferences.

This is in line with one of the responses of the interviewee:

> *Oluwakemi (pseudo name – female; 16years) said: Uhm I think it was really simplified because they described the topics, they gave examples, they gave us types, they gave us advantages, disadvantages and examples and they gave us test and they are quizzes there to help us test our knowledge about the apps, so yeah. They simplified it well. It's the same with that because they were diagrams, they were shapes to make us easily identify them like so if you see them anywhere you can like this is a flowchart, this and we know the meaning of all those shapes it made us identify different type of shapes and it was really…okay it was fun. From what I have learned on the app, I had confident if I am given the opportunity of learning these two topics that I will blast it in the WAEC exam.*

The mobile learning system offers an interactive and multimedia-rich learning environment, incorporating elements such as flashcards, animations, games, and quizzes, which cater to diverse learning styles and preferences. This interactive nature of the mobile learning system likely fostered greater engagement among students, stimulating their interest and motivation to learn as admitted by one of the interviewees: *It was fun. The diagram and the topic itself like algorithm, the topic itself it was so interesting, it was so interesting.* Furthermore, the use of multimedia resources has been found to enhance cognitive processes and promote active learning, leading to better knowledge retention and understanding among students (Lee et al., 2016). Also, a study conducted by Oladejo et al. (2024), they affirmed that technology provides students with easy-to-access information, accelerated learning, and fun opportunities to practice what they have learned.

In contrast, the conventional lecture method may not have provided the same level of interactivity and multimedia resources. Lectures are traditionally characterized by a one-way communication approach, with instructors delivering information to passive learners. Such a format does not effectively cater to individual learning needs and preferences, potentially resulting in lower levels of engagement and understanding among students (Oladejo et al., 2021). The study's results align with previous research that suggests that conventional lectures might be less effective in promoting active learning and student participation compared to technology-enhanced pedagogical approaches (Zheng et al., 2019).

Based on the data supporting our findings in this study, we conjectured that the significance of the mobile learning system's effect on academic achievement becomes evident when considering the broader implications for senior secondary school education, integrating technology-driven approaches, such as mobile learning, into the curriculum can enhance students' learning experiences and potentially lead to improved academic performance. This aligns with the current trend in educational practices that emphasize the incorporation of technology to create innovative and effective learning environments. By leveraging technology to deliver content in engaging and interactive ways, educators can effectively cater to the digital literacy and learning preferences of today's students (Adelana et al., 2023; Al-Azawei et al., 2017).

In research question two, we found a deferential impact on student's achievement in flowchart and algorithm based on gender. These results suggest that gender plays a significant role in determining the level of achievement among students exposed to the Mobile Learning System for learning flowchart and algorithm concepts (see Table 5).

The results of the analysis reveal the importance of considering gender differences in educational research and practice. The statistically significant difference in achievement between male and female students suggests that the MLS may have varying effects on the academic performance of male and female students. Factors such as learning preferences, technological proficiency, and engagement levels could contribute to the observed differences in achievement.

The impact of gender on academic performance is a complex interaction of various factors, and it is essential to avoid generalizations. While the findings indicate a significant difference in achievement, it is crucial to recognize that individual variations exist within each gender group. Other socio-cultural and environmental factors may also influence students' academic performance, and these should be considered when interpreting the results. Previous Studies show that males and females may have different learning preferences and styles (Valenzuela et al., 2019).

For example, males might prefer more hands-on and interactive learning experiences, which could be better facilitated through the technology-driven approach of the MLS. On the other hand, females may lean towards collaborative and group-based learning, which might be less emphasized in the MLS. The observed difference in academic achievement between male and female students in the context of learning flowchart and algorithm concepts using MLS could be attributed to several factors.

While it is crucial to avoid generalizations, research has identified some potential reasons for this gender difference.

1. Technological Proficiency: Gender differences in technology use and proficiency have been reported (Hunsaker & Hargittai, 2018). Males may generally be more familiar and comfortable with using technology, including mobile devices and digital learning platforms. This greater technological proficiency could lead to enhanced engagement and interaction with the Mobile Learning System, potentially resulting in better academic performance.
2. Confidence and Participation: Males might display more assertiveness and confidence in their academic abilities, leading to increased participation and active involvement in learning activities. Higher levels of engagement in the learning process are likely to contribute to improved academic performance.
3. Social and Cultural Factors: Societal expectations and stereotypes can influence academic achievement differently for males and females (Else-Quest et al., 2018). For instance, societal norms may encourage males to excel in certain subjects, such as mathematics and computer science, which are closely related to flowchart and algorithm concepts. These expectations might influence the motivation and self-perception of male students, leading to better academic outcomes.
4. Teacher and Classroom Dynamics: Teacher interactions and classroom dynamics can also play a role in gender differences in academic achievement (Brown et al., 2021). Educators' unconscious biases and differential treatment based on gender could impact students' confidence, engagement, and performance. The teaching approach and classroom environment may unintentionally favor certain learning styles, which could benefit male students more than females in the Mobile Learning System setting.

6. CONCLUSION

The goal of this study was to find an enduring solution to the unsatisfactory performance of secondary school students in Computer studies viz-a-viz concepts that are perceived as difficult such as flowchart and algorithm. We therefore explored the potency of the Mobile learning app (MLS) being a modern relevant pedagogy in breaking the barriers to meaningful learning of flowchart and algorithm in computer studies. Our findings show that the mobile learning app (MLS) does not only help students to learn better but also learn meaningfully (post-post-test performance). We also found that MLS could be an active agent for narrowing the long-coming gap in students' performance in science based on gender. Our findings from the students' responses suggested that MLS is capable of facilitating collaboration among teachers and students, thus enhancing the learning process among learners, developing their sense of belonging, and over time, enhancing their capacity for autonomous learning.

A study conducted by Mohammed et al (2010), proved that mobile technology brings the impact of mobile learning on traditional pedagogical learning strategies. The mobile learning model emphasizes mobile users, learning strategies, situated environment, and virtual group awareness. Many currently available mobile learning applications highlight the mobility, ubiquitous computing, and portability features to facilitate the learning process by utilizing these features, to create new innovative learning opportunities. The use of handheld devices like smartphones, iPads, PDAs, and tablets which can also be linked via communication systems like Wi-Fi or GPRS. These devices in themselves are agents of information as they can be utilized fully for in and out of classroom learning, due to their mobility and unlimited access to information and educational materials.

A major key conclusion derived was that the mobile learning system might affect gender while it is dangerous to make generalizations, it is important to note that various factors may be responsible for these, and equally important to note that student performance is still very much subjective to individual differences.

Ethical consideration

In carrying out this study, the permission and consent of the participating schools, teachers, and students were duly sought before any action was taken. Confidential information of the participants were secured and used for research purposes only. All the students that were involved in the study did not at any time miss any part of their lessons on the school-timetable schedule for them within the term. The teachers within the selected schools were helpful all through the study and this brought about a successful rapport with the students throughout the study period.

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